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The Strategy of Paleoanthropology: Early African Hominids Annual Luncheon Address: AAPA 1995

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ABSTRACT Discoveries of fossil hominids, particularly at Olduvai Gorge, Tanzania, in the late 1950s and early 1960s served as an important catalyst for stimulating the multi- interdisciplinary approach which now characterizes African paleoanthropology. While discovery of fossil hominids will always play a central role, it is the strategic implementation of a diverse set of inquiries which promises to generate the most rewarding and comprehensive details of how we became human. Field work by the Omo Research Expedition and the Koobi Fora Research Project contributed significantly to development of the strategy of paleoanthropology, emphasizing integration of specialists from geology, biology and the social sciences. In Ethiopia the ongoing Hadar Research Project has applied the integrated, multidimensional strategy of paleoanthropology resulting in important additions to our understanding of early hominid origins. The pace of fossil hominid discoveries is picking up in Africa, and there is every reason to believe that major contributions to human evolutionary studies will be forthcoming.

I was 16 years old when I saw headlines in a local Connecticut newspaper about the discovery of "Zinjanthropus" and, suddenly, fossil hominids entered my life. I didn't realize it at the time, but my fascination with the exotic skull from Olduvai Gorge was, in fact, my initiation into the field of paleoanthropology.

In a larger sense, the discovery of "Zinj" signaled the beginning of paleoanthropology as a multidisciplinary and, even more importantly, an interdisciplinary science. The study of the origins of humankind had always included various elements drawn from the biological and earth sciences. However, it took the special vision of Louis and Mary Leakey to articulate a research plan which went far beyond the initial discovery of a fossil hominid. With expanded funding, particularly from the National Geographic Society, Olduvai became the major staging place and testing ground for an approach which remains the centerpiece of our scientific investigations.

Looking back to the 1950s, the field was ripe for a major innovation. Work at Olduvai Gorge sparked an in-depth study of the "Zinj" locality, and scientists began to implement a new approach, one that integrated expertise from a diverse set of inquiries, into a strategic study which promised to flesh out details of how we became human. Exploration and discovery will always be essential ingredients of paleoanthropology. But now, it is the carefully articulated and targeted approach to answering questions about the human career that provides the most significant breakthroughs.

Ever since the 1950s the New Paleoanthropology has become more sophisticated in the field and in the laboratory. Especially vital in contributing innovations was the Omo Research Expedition in southern Ethiopia, under the direction of Yves Coppens and F. Clark Howell and the still ongoing investigation of circum-Lake Turkana, initiated by Richard Leakey and the late Glynn Isaac. These two major projects, be-

ginning in the late 1960s, contributed greatly to the approach which characterizes paleoanthropology today (Coppens et al., 1976).

There is still no substitute for arduous and lonely foot survey and excavation for finding fossils and recovering artifacts. But remote sensing (Asfaw et al., 1990) is playing a very important role in helping us discover new fossil deposits. Global positioning systems allow us to pinpoint, with unprecedented accuracy, the precise coordinates of fossil sites. Fossilized pollen grains yield insight into past environments. Paleontology provides a better understanding of the animals which lived alongside early hominids, as well as an enriched view of ancient faunal communities. Archeologists replicate tools made by our ancestors and determine how they might have been used.

Earth scientists study sediments to reconstruct past geological events and assist in understanding the context in which our ancestors lived. Isotopic dating techniques provide a precise temporal framework for human evolution, by dating even single crystals of volcanic rock.

Classical comparative anatomy is essential for reconstructing the geometry of hominid phylogeny; however, innovations in evolutionary theory since the Modern Synthesis, such as punctuated equilibria, the selfish gene, kin selection, species recognition and sociobiology, have richly expanded the traditional evolutionary framework in which hominid species are understood. The implementation of sophisticated imaging technology even allows us to examine the internal structure of bones and teeth. The use of computers to reconstruct and morph fossils is one of the newest technologies extending our ability to see beyond the fossil fragments themselves. Functional analysis of anatomy, utilizing biomechanical models, provides insights into locomoor adaptations and the constraints on bone structure.

Paleoanthropology is moving away from the simplest image of the "Bones Race." Exclusive interest in finding the largest-brained, the oldest, or the most complete fossil is really a concoction of the media, not of the science. Our real goal is to seek knowledge about human origins, or as Thomas Henry Huxley said, about "Man's Place in Nature" (Huxley, 1863).

It occurs to me that the Hadar project with which I have been involved since 1972 is a good example of the New Paleoanthropology—the integrated, multidimensional model—I mentioned as the great advance in paleoanthropology that began in the 1950s. The Hadar Research Project has completed four very successful field seasons (1990, 1992–94). The return to Hadar was at the invitation of the Ethiopian Ministry of Information and Culture (previously the Ministry of Culture and Sports Affairs) and the Center for Research and Conservation of Cultural Heritage. The renewed research has been under the coleadership of William H. Kimbel, Robert C. Walter and myself, all of the Institute of Human Origins.

Previous field work at Hadar in the 1970s contributed substantially to our storehouse of pre-3.0-million-year-old hominids, but also left a series of unresolved issues about the geology and geochronology of the deposits. Moreover, a number of questions concerning the systematics and paleobiology of the Hadar hominids required further testing and clarification.

Resolution of these considerations required the phrasing of new questions, the application of new methodologies, the implementation of a comprehensive and strategic survey program, as well as inclusion of new personnel who had wide field experience at other sites throughout the Rift Valley.

The well-dated, fossil-bearing deposits in the Lake Turkana Basin provided an important framework in which to view the tempo and mode of evolutionary change in hominid evolution. Widespread and well-dated occurrences of volcanic sediments permitted the precise dating of sequences surrounding Lake Turkana. Much of this extraordinary work has been under the leadership of Frank Brown from the University of Utah (Brown and Feibel, 1988). His use of chemical fingerprinting to recognize and correlate tuffs throughout the Turkana region and the horn of Africa, combined with an innovative approach incorporating data from Deep Sea Cores to further substantiate correlations and recognize volcanic sources, is especially noteworthy.

Accurate dating of the Hadar Formation had been, however, hampered by the general absence of volcanic sediments amenable to radioisotopic dating. Instructive comparison of the temporal placement of the Hadar hominids with other hominid-bearing sequences in eastern Africa was, therefore, seriously limited. Earlier geochronological and biostratigraphic considerations strongly implied that the Hadar hominids were older than 3.0 million years. However, the precise dating of important finds such as A.L. 288-1 and the important collection from A.L. 333 was impossible.

With the application of Single Crystal Laser Fusion (SCLF) techniques, argon dating technology, during the 1980s, became considerably more refined (Lewin, 1991). This new methodology, in contrast to whole rock, potassium-argon dating, depends on analysis of single crystals of volcanic origin for which $^{40}Ar/^{39}Ar$ ratios could be experimentally established.

Renewed geological sampling at Hadar revealed not only the presence of previously unrecognized, dateable tuff horizons, but also facies of tuff horizons, such as the SHT which contained sufficient feldspar crystals for SCLF technology (Fig. 1).

Following an intensive resampling of the 200-m-thick type section of the Hadar Formation, both paleomagnetic and $^{40}Ar/^{39}Ar$ dating resolved many of the earlier dating problems. No hominid at Hadar is older than 3.4 million years based on dates for the Sidi Hakoma Tuff of 3.4 million years. Alteration of the Kadada Moumou Basalt made earlier attempts at dating this horizon impossible. Careful sampling and the application of the new SCLF dating technology produced a date of 3.28 million years for the lava.

One of the most useful marker horizons at Hadar, the Triple Tuffs, could not previously be dated because of the virtual absence of feldspars. However, recognition of a facies of the TT-4 permitted recovery of sufficient crystals to establish a date of 3.22 million years for the horizon. A younger date of 3.18 years for the Kada Hadar Tuff is consistent with its stratigraphic position above the TT-4. Finally, the BKT-2 ash horizon, higher up in the geological section, provided a date of 2.92 million years. Preliminary dates for the BKT-3 indicate an age of 2.0–2.3 million years for deposits near the top of the Hadar Formation.

These new absolute dates within the Hadar Formation (Walter and Aronson, 1993; Fig. 1) are extremely precise. For example, the TT-4 and KHT tephra are dated to +10,000 years. The hominids from A.L. 333 are situated between these two volcanic horizons, implying that the First Family site, as it is sometimes called, is dated between 3.18 and 3.22 million years—close enough to please most of us. The A.L. 288-1 partial skeleton, which had been floating in time, is located immediately below the KHT dated to 3.18 million years.

Paleomagnetic sampling of the Hadar Formation provides an independent check on the argon chronology. Both the Mammoth and Kaena subchrons were confirmed in the Hadar Formation (Renne et al., 1993).

Resolution of the ambiguity in the geochronological framework at Hadar came about as the result of careful collaboration between geologists involved with stratigraphic mapping and those collecting sediments for Argon dating and paleomagnetic study. Success of the dating program at Hadar is an excellent example of how exceptional results can be obtained through additional field experience, improved technology and close scientific collaboration. Implementation of such an interdisciplinary approach has transformed the Hadar Formation from one of the least well-dated, to one of the best calibrated hominid-bearing sequences in Africa.

Results of extensive laboratory study of the 250 hominid specimens collected at Hadar in the 1970s were presented in a series of scientific articles and a monograph, published as the April 1982 issue of the *AJPA* for which our Association's journal received an important award.

After careful analysis, it was concluded that the Hadar hominids consisted of a single species, bipedal, craniodentally primitive, and highly sexually dimorphic. Based on comparisons with the hominid fossils from Laetoli, Tanzania, the combined sample was assigned to *Australopithecus afarensis* (Johanson et al., 1978). However, since the publication of these conclusions a number of our hypotheses have been questioned.

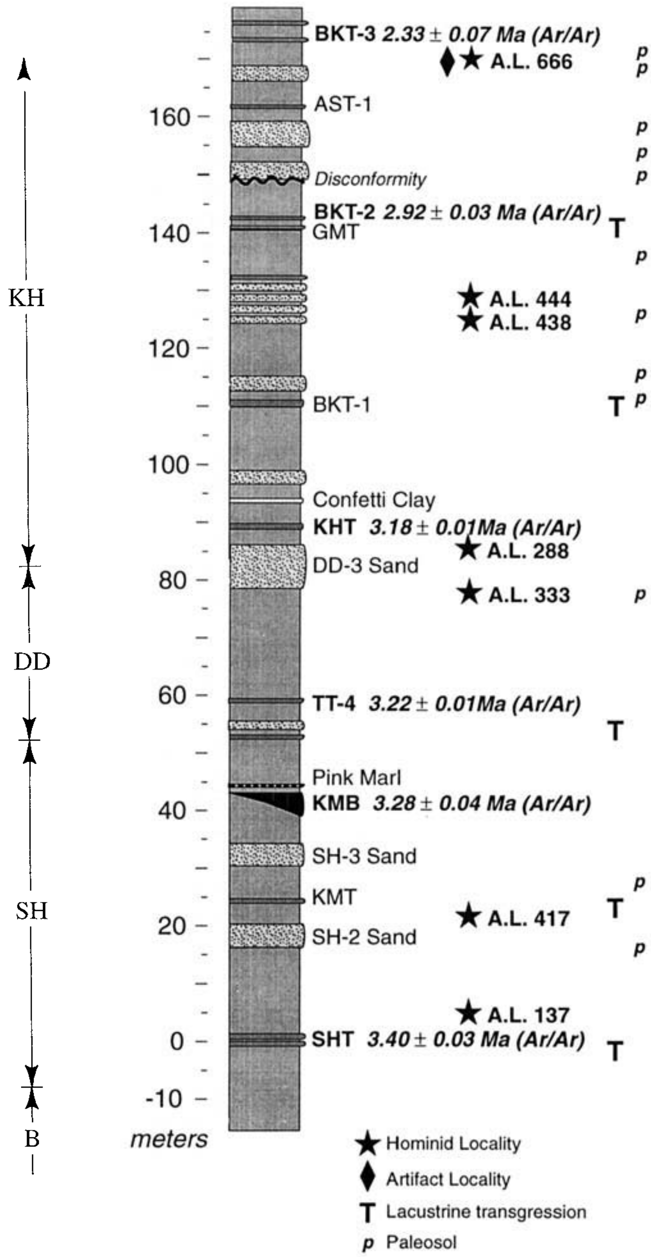

Fig. 1. Hadar Formation A composite section. Drawn by Robert C. Walter.

Some workers saw more than one taxon at Hadar and the degree of bipedality in *A. afarensis,* in spite of the Laetoli footprints, has continued to be hotly debated.

Controversies such as these can be very good for science. They stimulate new perspectives and awaken new hypotheses which often precipitate new approaches to test

them. Controversy signifies that a science is alive and maturing.

Recovery of additional fossil hominid specimens from the Hadar Formation was seen as central to clarification of a number of issues concerning the paleobiology of the Hadar hominids. These issues include: the taxonomic unity of *A. afarensis;* the pattern of sexual dimorphism; and the locomotor repertoire of the Hadar hominids. Discovery of a skull of *A. afarensis* was given high priority since not a single reasonably intact skull was found during the earlier field seasons at Hadar. Another critical question addressed the issue of what happens to *afarensis* after "Lucy," the youngest specimen of this species.

A carefully articulated plan was devised to not only revisit previously known productive hominid-bearing areas, but to extend survey into geographic areas and stratigraphic horizons that had not yielded significant fossil fauna. Utilizing aerial photographs, a working photomosaic was compiled to assist the survey teams in the field. Furthermore, foot survey teams, composed of scientists and highly skilled local Afar people, were provided an opportunity to study casts of previously found hominids and encouraged to develop a better appreciation for bony anatomy.

A review of earlier hominid finds at Hadar revealed that except for the A.L. 288-1 skeleton, and a few other specimens, from the very lowest horizon of the Kada Hadar Member, all hominid finds were from the Sidi Hakoma and Denen Dora Members. Hence, the hominids spanned a 200,000 year time interval between 3.2 and 3.4 million years ago. Although sediments stratigraphically above Lucy were fossil-poor, intensive survey of those deposits was considered important in order to glimpse the nature of post-Lucy anatomy.

Of the 74 additional hominids recovered from Hadar, during the course of four field seasons since 1990, 10 derive from sediments younger than Lucy. In fact, two of the most significant finds are situated in the middle reaches of the Kada Hadar Member, making them approximately 3.0 million years old. These finds doubled the temporal range for hominids at Hadar from 200,000 to 400,000 years.

Most importantly, one of the specimens from A.L. 444 constitutes a fairly complete adult skull (Fig. 2), the first of *A. afarensis* (Kimbel et al., 1994). The detailed comparative anatomical study of the specimen is underway, but already it is evident that the anatomy of the skull is fully consistent with the earlier reconstruction of a male *A. afarensis* skull. Possessing large canines, as well as strong muscle markings, the skull is of a male. The associated mandible possesses a deep corpus, but the robusticity index at M_1 of 56 falls just below the Hadar mean of 58.

The frontal bone, poorly represented in earlier samples, lacks a chimpanzeelike supratoral sulcus. Unlike later robust *Australopithecus* a frontal trigone is absent and the distance across the postorbital constriction is large, absolutely, and relative to facial breadth. The overall morphology of the frontal bone is shared with the 3.9-million-year-old Belohdelie frontal.

The other specimen, A.L. 438-1, from the middle KH Member is a partial upper limb skeleton, associated with a mandible and frontal fragment. The ulna, the most complete *Australopithecus* ulna known, at 268 mm in length, is 22% longer than Lucy's. Aside from size differences, this ulna is anatomically identical with Lucy's, supporting the pattern of considerable sexual dimorphism previously documented for the Hadar sample.

A large, heavily built, presumably male humerus, A.L. 137-40, was recovered from the lower Sidi Hakoma Member. It is virtually identical to the Maka humerus, also dated to about 3.4 million years. A preliminary length estimate of 295 mm makes the A.L. 137 humerus some 24% longer than Lucy's. Using the A.L. 438 ulna and the A.L. 137 humerus, a ulna/humerus index of about 91% is derived; Lucy's is about 92.5%. The mean for chimps is 95% and only 80% for modern humans. The combination of a short, robust humerus and long forearm may reopen debates about *A. afarensis* climbing and/or feeding behaviors.

The dental sample for Hadar has been increased by 70% and the measurable mandible sample by 50%. The size variations seen in the newly recovered dentition and mandi-

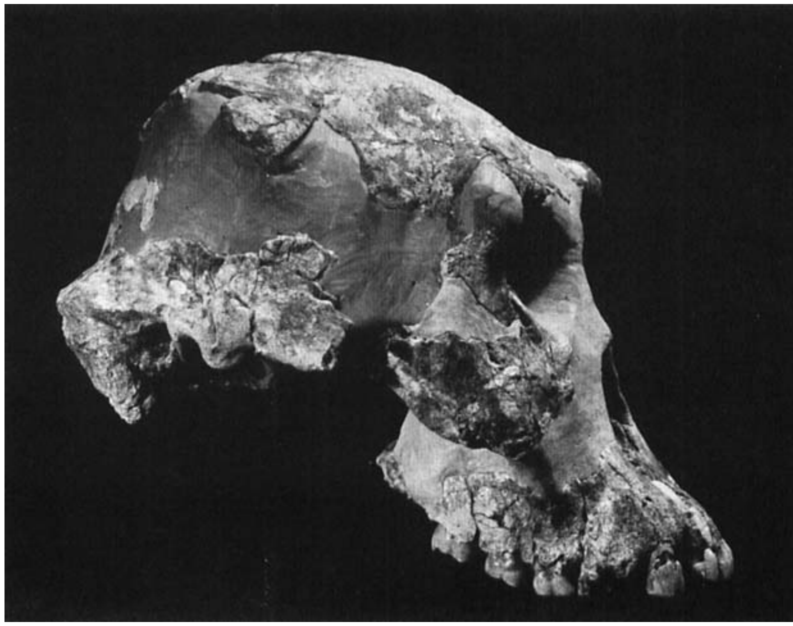

Fig. 2. A.L. 444-2, a 3.0-million-year-old male cranium (mandible not shown) of *Australopithecus afarensis* from Hadar.

bles as well as a partial female face (A.L. 417-1d) from the middle Sidi Hakoma Member are all consistent with a single taxon at Hadar. Despite the addition of scores of new specimens to the Hadar hominid sample, the one-species interpretation still resists refutation where samples are sufficiently large to warrant meaningful tests.

Consideration of these more recent Hadar hominid finds in a broader perspective may tell us something about the tempo of evolutionary change in *A. afarensis*. Placing the Belohdelie frontal in the same species as the A.L. 444 skull implies at least a 900,000-year range for *A. afarensis*. Additionally, it may also imply a fairly long period of stasis for this taxon, at least in so far as preserved anatomy permits. The Hadar sample of *A. afarensis*, spanning some 400,000 years, constitutes, at 324 hominid specimens, the best sample of pre-3.0-million-year-old hominids in the world.

One example of the strategic approach was the implementation of a field strategy which identified important horizons yielding younger faunal and archeological occurrences in the Hadar deposits. While the 3.0- to 3.5-million-year time slice is hominid-rich, the potential of the later geological horizons is just beginning to be realized. We know from discoveries elsewhere that the 2.0 to 3.0 million year time range was an especially momentous one in hominid evolution. It was during this period, and perhaps between 2.5 and 3.0 million years ago, that the robust australopithecine clade arose, already documented by the Black Skull (KNM-WT 17000) at 2.5 million years ago (Walker et al., 1986). The first culturally patterned behavior arose during this time period in the form of simple, Oldowan-like stone tools. Finally, the origin of our own genus probably occurs in this exciting time range as well.

The very upper reaches of the Kada Hadar Member constituted a terra incognita for the Hadar Research Project. Stratigraphically younger than 3.0 million years, presumably these strata sampled the elusive time period between 2.0 and 3.0 million years. Although fauna is exceptionally rare in these deposits, a targeted survey led by Gerry Eck brought

about some interesting discoveries including the first hominid specimen of the genus *Homo* (Kimbel et al., in press).

In one area a modest, but interesting collection contains *Equus, Gazella* and other fauna which suggest a biostratigraphic age younger than Member C from the Shungura Formation. Especially tantalizing is the presence of a much younger looking fauna, stratigraphically higher in the Hadar Formation. Presence of a very evolved *Elephas* suggests a tentative age of around 2.0 million years. There are also indications in the fauna of a change in paleoenvironment from the more forested *A. afarensis* levels to more open habitats (Eck and Reed, 1996). Further field work in this area will add vital information on suggestions that climatic change may have played a role in prompting faunal turnover and generating a miniadaptive radiation in the Hominidae.

This is a very exciting time to be involved in paleoanthropology. Not only is the storehouse of fossil hominids growing every day, but carefully articulated strategies are being widely implemented. Opportunities for field work have, in fact, never been better. A few examples include central Asia, China, Java, Spain and, of course Africa, especially Tanzania, Kenya, Malawi, South Africa, Eritrea and, at long last, Uganda. In Ethiopia, where the Institute of Human Origins team has worked, there are still thousands of square miles of fossiliferous deposits which are virtually unexplored.

We may be moving into another Golden Decade of Discovery in paleoanthropology, akin to the 1970s. Exciting finds will be made in the dynamic 2.0- to 3.0-million-year time slice. Strategically planned fieldwork will add greatly to an understanding of faunal turnovers, climatic change, and especially the possibility of a hominid radiation. After all, the highest diversity of hominid taxa occurs around 2.0 million years ago with *A. boisei, A. robustus, Homo habilis, H. ergaster* and *H. rudolfensis.* If we accept the notion that we will always underestimate the number of taxa in the fossil record, might we expect the human family tree to become bushier (Tattersall, 1986)?

The other, hitherto elusive, but remarkable period demanding further exploration is that back beyond 4.0 million years. The recent announcement by Tim White's group of 4.4-million-old hominids from the Middle Awash in Ethiopia is very exciting (White et al., 1994). Thus far fairly fragmentary, the fossils from Aramis appear to be more chimplike, especially in the thin enamel on the cheek teeth and the primitive lower first deciduous molar. There seems to be little question that these hominids represent an older species. Initially assigned to *Australopithecus ramidus,* in a corrigendum White et al. (1995) erected a new genus for the Aramis hominids: *Ardipithecus.*

Although a fairly complete skeleton of this early hominid taxon has been reported (White et al., 1995), no details are yet available. Unfortunately we will have to wait several years, after preparation and laboratory study is complete, before we well know much more of the Mystery Skeleton.

Renewed work at Kanapoi, situated southwest of Lake Turkana by Meave Leakey, has been rewarded with the recovery of nine cranial, dental and postcranial hominid specimens, as well as 12 specimens from east of the lake at Alia Bay (Leakey et al., 1995). These finds derive from sediments dated to between 3.9 and 4.2 million years ago. In many respects they are reminiscent of *A. afarensis* in mandibular shape, tooth row shape, enamel thickness and so on. However, the character state of many of these features is significantly more primitive than that seen in *A. afarensis.* The authors are fully justified in giving them a new species name, *Australopithecus anamensis.*

A. anamensis appears to be an ideal candidate for direct ancestry to *A. afarensis.* Most of a right tibia, preserving the proximal and distal ends, indicates bipedality. The evolutionary relationship between the earlier, much more primitive *Ardipithecus* and later *Australipithecus* is at this time impossible to ascertain, although it has been suggested that *Ardipithecus* may be a sister taxon (Leakey et al., 1995).

I have been fortunate to have had an exciting and scientifically rewarding career in this field, beginning with my first travels to Africa in 1970. Over the years working with a diverse group of exceptional colleagues I have been able to add to our understanding

of human origins. More recently, my work in Africa has been enriched by participating in the training of African nationals, some of whom are now actively pursuing their own research projects. Doing the science, in the field and in the lab, continues to be a source of tremendous satisfaction and, in a science as young as ours, one filled with lots of surprises.

Not everyone wants to be a paleoanthropologist, but it is obvious that the subject of origins, especially *our* origins, enjoys a remarkably large public audience. Through popular books, films and public presentations, I have had the joy of sharing our science with nonspecialists.

Armed with my union card from the University of Chicago, I was not trained or prepared for the overwhelming demand to translate how our science works for the public. However, over the years, I have become a strong believer that scientists do have a responsibility to share their findings with a broader constituency. We can all recite cases in which a lack of public understanding of science leads to appalling consequences—lack of support for strategic initiatives, voter confusion when presented with the need for science-based decisions, confusion about fundamental facts, vulnerability to misinformation and bogus arguments.

To a significant extent, it is our task, individually and collectively, to bridge the information gap however we can. Our goal is to correct the misunderstandings, help the public understand not just *what* we know, but *how* we know it, and *why* it is important. We know science is relevant, and we must get that message out to the general population. Our job is to ensure we do not, however inadvertently, send a message to the public that is beyond their ability to understand. We should concentrate on enriching their knowlege of how science affects, enriches, protects and challenges them.

Doing good science continues to be our major goal, but improving scientific literacy and facilitating communication of science to the public is very important. We must, when it comes to "Scientific Creationism," counter the dissemination of tremendous misinformation as well as the misuse of the scientific method. Not all of us have the will or the ability to become skillful scientific communicators. This is certainly understandable but I truly believe that it is essential for some of us to participate in the dissemination of science to the public.

Especially now that the political climate in Washington demands more socially and economically relevant research, there is a premium on a discourse between scientists and the public.

Paleoanthropology can play a role, but it has had its share of image problems. I recall a number of years ago when the late Nobel Prize winner Luis Alvarez likened paleontologists to stamp collectors. This was a heavy blow because it implied that we are not serious scientists.

This unflattering view of our science receives support from the media who continue to characterize paleoanthropologists as being motivated by the "Bones Race." It has even skewed the views of some of our own. I still recall how stunned I was to read the following:

> Paleoanthropology has always been a curious business. But during the past 20 years, it has also become a big and, sometimes, bad and ugly business, in which science is adulterated with show biz. Megabucks are preeminent in the search for the taproot. The research expeditions and follow-up studies are costly; and, one's fortune can be made by shrewdly publicizing fossil discoveries and evolutionary stories based upon them. As in politics and Hollywood, visibility is a vital springboard to power and money. Concomitantly, new and old bones of contention sometimes lapse to mere props in the soap operas and political maneuvers of media-mongering paleoanthropologists. (Tuttle, 1988:391)

Too often we are depicted as aimlessly wandering around the Rift Valley, clad in khakis and wearing a pith helmet, hoping to stumble on a major discovery, finding the holy grail of human evolution and instantly being catapulted into fame. Equally damaging is the old view that from a single tooth we can inferentially and unambiguously reconstruct the lifeways of our distant ancestors.

In order to counter such views, it is vital that we reach as large an audience as possible and illustrate for them that our research is based on the scientific method, that it articulates strategies designed to solve specific

problems. Maybe it is the discovery of a skull or skeleton that piques public interest, but we must then take this opportunity to explain how we study, describe, interpret, debate and resolve divergent hypotheses about the evidence for human evolution.

Whether we like it or not, there is no better way to reach the largest possible audience than through the medium of television. When *Nova* invited me to host a three-part series, entitled *In Search of Human Origins,* I knew it was an important opportunity.

For many, it was the second hour, which addressed the chauvinisitic view of man the hunter, that was the most successful. In previous programs on human evolution, a parade of skulls and talking heads had failed to captivate folks in their living rooms. On the other hand, watching Rob Blumenschine and me follow carnivores around for the better part of an hour, the viewer saw firsthand how we test hypotheses and make inferences about the probable behavior of our ancestors.

Viewed by some 50 million people, the response to the series has been very gratifying. Perhaps the series will attract new scholars, young women and men who will react much as I did when I read about "Zinjanthropus" 35 years ago. Perhaps other viewers will understand better what constitutes true evidence of evolution and be less susceptible to the antiscience rhetoric of creationists, who are working so hard in some communities to undermine the teaching of human evolution and promote ignorance. And, perhaps, others who see *Nova* will simply understand that knowledge of our evolutionary origins matters to them on some personal, visceral level, and that they want to see our work advance and to support it however they can. I hope that when decisions are made concerning federal and private funding for our research, they will no longer be made in ignorance.

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This paper is dedicated to the memory of the late Dr. Albert A. Dahlberg. Al was my most important mentor at the University of Chicago during my graduate days. He warmly welcomed me into his research lab, provided a National Institutes of Dental Research Traineeship and generously gave of his time and advice. If I have made any contributions to paleoanthropology, it is directly because of Al's leadership and compassion.

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